LITANI RIVER BASIN MANAGEMENT SUPPORT PROGRAM

WATER QUALITY DATABASE MANAGEMENT

March 2012

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ACRONYMS

BAMAS	Litani Basin Management Advisory Services
BOD	Biochemical Oxygen Demand
CCME	Canadian Council of Ministers of the Environment
Cl^-	Chlorine
CND	Conductivity
DO	Dissolved Oxygen
IDRC	International Development Research Center
GIS	Geographic Information System
LRA	Litani River Authority
LRBMS	Litani River Basin Management Support
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
PO_4^{3-}	Phosphate
SO_4	Sulfate
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WQI	Water Quality Index

EXECUTIVE SUMMARY

The Litani River Basin Management Support (LRBMS) program along with the Litani River Authority (LRA) have sampled or acquired a number of water quality measurements throughout the Litani River Basin. To date, this extensive data has not been centrally catalogued or managed to allow for analysis along with reporting to stakeholders. Through this LRBMS database management work, various studies over the past 20 years were integrated into a central database, inclusive of over 5000 LRA data points from the past 5 years. This document outlines the work that has been done for this database along with steps for utilizing the data.

After evaluating options, a robust, yet simple database was selected that utilizes Excel. The primary reason for selection is that Excel is typically the platform program for most databases, and Excel has an easy integration with GIS. In the future, this database could transition to a more robust platform such as Microsoft Access or another water quality analysis program, such as AquaChem.

Water quality data is stored in a main sheet of the database, and data is sorted and filtered through selected categories. Users can sort data by water quality parameters, specific time ranges, or by a particular study. The ability to sort and filter then allows users to easily generate graphs and reports as necessary.

The database also allows users to generate two different monthly reports; one which is more technical in nature (for internal LRA staff and ministries) and the other for public information. Within the database, the technical report is generated by entering the current month's water quality data (typically from the LRA's monitoring program), and then tables and graphs are automatically filled in for use in the monthly report.

The public reporting is mainly based upon a Water Quality Index (WQI) which was developed for the LRA. A WQI is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. This can be especially meaningful to residents who want to know about the state of their local water bodies and for managers and policy makers who require concise information about those water bodies. The WQI developed for the LRA takes the monthly sampling parameters and uses standardized curves to generate index values. Once measurements have been taken, they are entered into the database and overall WQI values can be used for public reporting.

This database work will help the LRA to manage their water quality data while also managing water quality information throughout the basin. Through the functionality of the new database information can be disseminated to stakeholders and the public for more active participation in improving water pollution.

ملخص تنفيذي

قام برنامج دعم ادارة حوض الليطاني بالتعاون مع المصلحة الوطنية لنهر الليطاني بأخذ عينات او الحصول على قياسات لنوعية المياه في مجمل الحوض المذكور. انما لتاريخه لم تبوب هذه المعطيات الشاملة او تنظم للسماح للمعنيين بالأمر من تحليلها او ترجمتها.

وقد حاول البرنامج لدعم ادارة حوض الليطاني من خلال عمله لإدارة قاعدة البيانات بضم الدراسات المتعددة التي اجريت في خلال العشرين سنة الماضية في قاعدة بيانات مركزية. بما في ذلك 5000 بيان لنقاط قياس للخمس سنوات الماضية كانت المصلحة الوطنية لنهر الليطاني قد قدمتها. وتبين الوثيقة الحالية العمل الذي تم لقاعدة البيانات هذه وكذلك الخطوات لإستعمال البيانات المذكورة

بعد دراسة الخيارات جرى اختيار قاعدة بيانات قوية وبسيطة تعتمد نظام "اكسيل".وكان السبب الساسي لهذا الإختيار ان ال"اكسيل" هو البرنامج النموذجي الذي يعتمد كمنطلق لأكثر قواعد البيانات وهو يضم بسهولة لنظام المعلوماتيت الجغرافي.

وفي المستقبل يمكن لقاعدة البيانات هذه ان تحول الى منطلق أكثر متانة "كميكروسوفت اكسيل" او اي برنامج اخر لتحليل نوعية المياه "كأكوا كيم".

تحفظ معطيات نوعية المياه في بطاقة رئيسية من قاعدة البيانات ثم تفرز وتصنف في فئلت مختارة. ويمكن لمستعملي القاعدة المذكورة فرز المعلومات كل عامل من عوامل نوعية المياه وضمن اوقات معينة او اي دراسة خاصة. وامكانية الفرز والتصنيف تسمح للمستمل ان يرسم البيانات ويضع التقارير عند اللزوم.

ويمكن لقاعدة البيانات أن تسمح للمستعملين بوضع تقريرين شهريين مختلفين: الأول يغلب على طبيعته الطابع الفني (للتداول الداخلي في المصلحة الوطنية لنهر الليطاني والوزارات) والآخر للاعلام العام. وضمن قاعدة البيان ينتج التقرير الفني بادخال معطيات نوعية المياه للشهر الجاري (يؤخذ من برنامج المراقبة العائد للمصلحة الوطنية لنهر الليطاني) وبعد ذلك تدخل اللوائح و الرسمات البيانية بصورة تلقائية (اوتوماتيكية) لاستعمالها في التقرير الشهري.

تبني التقارير العامة اجمالا على مؤشر نوعية المياه الذي وضع للمصلحة الوطنية لنهر الليطاني. يعني مؤشر نوعية المياه تلخيص عدد كبير من معطيات نوعية المياه وترجمتها بعوامل بسيطة لإعلام الإدارة والجمهور بشكل متماسك. وهذا يعني الكثير لسكان المنطقة بصورة خاصة الذين يريدون معرفة أوضاع مواردهم المائية المحلية وكذلك للمسؤولين عن إدارة المياه المذكورة وصانعي القرار الذين يحتاجون الى معلومات موجزة عن هذه الموارد. وقد أخذ مؤشرية المياه الذي وضع للمصلحة الوطنية لنهر الليطاني عوامل الأعتيان الشهرية واستعمل منحنيات بيانية قياسية لإنتاج قيم المؤشرات. وبعد أخذ القياسات والكيول تدذل نتائجها في قاعدة البيانات وبالإمكان الإستفادة من مؤشر نوعية المياه في التقارير العامة. وستساعد أعمال قاعدة البيانات هذه المصلحة الوطنية لنهر الليطاني لإدارة معطيات نوعية مياهها كذلك بينما تقوم بادارة المعلومات عن نوعية المياه في مجمل الحوض. ومن خلال المعلومات في قاعدة البيانات الجديدة واهداف استعمالاتها يمكن توزيعها ونشرها بين المعنيين بالأمر والجمهور لمشاركة مقالة اكثر في مكافحة تلوث المياه.

1. WATER QUALITY DATABASE MANAGEMENT

There have been a number of studies performed in the Litani River Basin over the past 20 years that have aimed to characterize water quality. These studies have advanced the understanding of surface and groundwater in the basin, although the data itself has not been centrally managed. This document provides an overview of water quality data in the Litani River Basin, how to use this data, and the best approaches for management.

1.1. DATABASE SOURCES

The various studies and sampling performed in the Litani River Basin has become the basis for the LRBMS database. The following data sources and studies are included in the database along with the sampling dates and the season for which samples were collected. One of the most important aspects of the database is the addition of the LRA's internal monitoring samples which includes over 5,000 new data points. A list of all the parameters for which there is data is listed in Appendix C.

Study	**Sampling Dates**	**Seasons Sampled**	**Year Study Published**
Jurdi et al	1995	Dry	2002
Korfali et al	1998	Dry	2006
Swedish **MVM** Consult AB	1998 – 1999	Dry & Wet	2000
Saad et al	2000 – 2001	Dry & Wet	2005
Shaban & Nassif	2004	Dry	2007
International Development Research Center (**IDRC**)	2004 – 2006	Dry & Wet	2007
Litani Basin Management Advisory Services (**BAMAS**)	2005	Dry & Wet	N/A
Saad et al	2007	Dry	2009
Litani River Authority (**LRA**) Monitoring	2006 – 2011	Dry & Wet	N/A
Korfali & Jurdi	2008	Dry	2010
LRBMS	2010	Dry	N/A
LRBMS	2011	Wet	N/A
ELARD	2011	Wet	N/A

1.2. DATABASE SELECTION

This Excel database is a first step towards managing and reporting water quality. The most powerful aspect of the database is the ability to transition easily between Excel and other database programs. GIS will be used as the main method to present water quality spatially, but Excel is much better and analyzing water quality data and developing averages, trend lines, and graphical displays over time. Eventually, if the LRA wants to do more in-depth analysis of water quality they may want to look into other software such as AquaChem.

The evaluation of potential database programs is expanded upon further in Appendix A: Database Selection Summary

1.3. DATA ORGANIZATION

The data is organized in Excel as one large database including all studies, parameters, and results. There are both water and soil samples included in the database, and it should be noted that soil samples are noted as either categorized as “River Sediment” or “Lake Sediment”.

This database was created to be integrated with GIS and an easy transition between the two. GIS is an incredibly powerful tool that allows the LRA to view data by location and create various plots for given water quality. The database has been set up so that it corresponds with GIS naming and there can be an easy transition between Excel and GIS. Although there are some tasks outside of GIS, such as trends, time-based plots, etc, that would be most useful in Excel. For this reason Excel has been used as the primary for storing data, where it can be built upon for other uses.

Each sample location is given an ID that corresponds with the northing and easting coordinates of GIS. In addition, the database is laid out with the same parameters and descriptions as in GIS so there is no need to make changes for usage between the two.

1.4. DATABASE CONSISTENCY

Controlling data and maintaining its integrity is critical to the accuracy and use of the database. There should be one version of the database used to retain all data as the primary source. If reports need to be generated or any other manipulation of the data, a separate version should be saved for that specific purpose.

For example, the database is saved as "LRBMS Water Quality Database 2012" – this naming does not change. If new water quality information is added to the database, the database would still keep its naming as the primary source. But if one wants to generate a report for February 2012 sampling data, to take averages, create plots, etc – then a different version should be saved, such as "Feb 2012 Monthly WQ Report".

In order to make sure that the LRA can maintain a master copy of the database, it is recommended that the LRA consider using a "locked" version of the database if it's used for distribution. This way any other users outside the LRA staff can view and use the data, although this data cannot be changed or manipulated.

1.5. ADDING DATA TO EXCEL AND GIS

In order to keep sampling results consistent and to be able to integrate into GIS for plotting purposes, new data should be entered in the same format as the template. Since GIS plots information spatially, it is very important to have the northing and easting coordinates for each new sample. Once sampling data has been collected it is assigned an ID, noted in the database as "Location ID". There may be multiple samples (or studies) for the same Location ID. To integrate with GIS the following steps are taken to enter new data:

1. When adding sampling information to the database, the predefined Excel format should be used.
2. When adding the LRA's monthly water quality sampling:
    a. Add the sampling data to the LRBMS Water Quality Database under the tab "Current Month Data"
    b. Once the data has been added, it should be copied and pasted at the bottom of the "LRBMS Database" tab
    c. This new information should also be reported to the GIS manager (Wassim Katerji) for integration into GIS
    d. The reporting tables under "LRA Reporting" are auto-generated once the values have been entered into the "Current Month Data" sheet.
3. When sample data comes from an Existing Locations separate from the LRA monthly sampling:
    a. Make sure that the data being entered is new data and is not already in the database (in order not to create duplication);
    b. Request that the GIS Manager (currently Wassim Katerji) performs a search to determine the unique location ID (ULID). Or a search can be performed independently

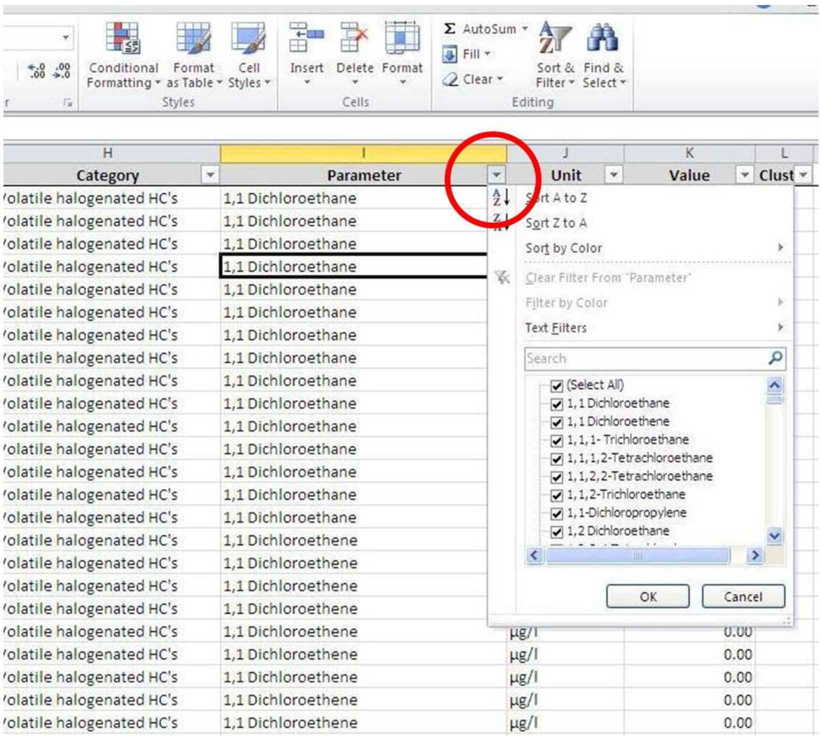
by searching the GIS layer (WQ_Sampling_Locations Layer in the Geodatabase) for the locations;
   c. For each existing location, check the unique location ID (ULID) and add it in the Excel sheet under "Location ID" to correspond with the sampling data;
   d. Have the GIS Manager convert the Excel Sheet to a table in Microsoft Access or perform the conversion, and then integrate into GIS.
4. When sample data comes from a New Location separate from the LRA monthly sampling:
   a. Make sure that the data being entered is new data and is not already in the database (in order not to create duplication);
   b. Request that the GIS Manager (currently Wassim Katerji) add a sampling layer to ArcMap. Or In ArcMap, add the sampling layer (WQ_Sampling_Locations layer in the Geodatabase);
   c. A new location ID will need to be created. Insert the location of each new sample as a new point (make sure the coordinates are in Stereographic Projection), and create a new incremental location ID (ULID) in the table of attributes;
   d. For each location, add its related new ULID in the Excel sheet;
   e. Have the GIS Manager convert the Excel Sheet to a Table in Microsoft Access Data or perform the conversion, and integrate into GIS.

If the data is collected in an Access table from the start, the step of converting the Excel sheet into an Access table can be omitted.

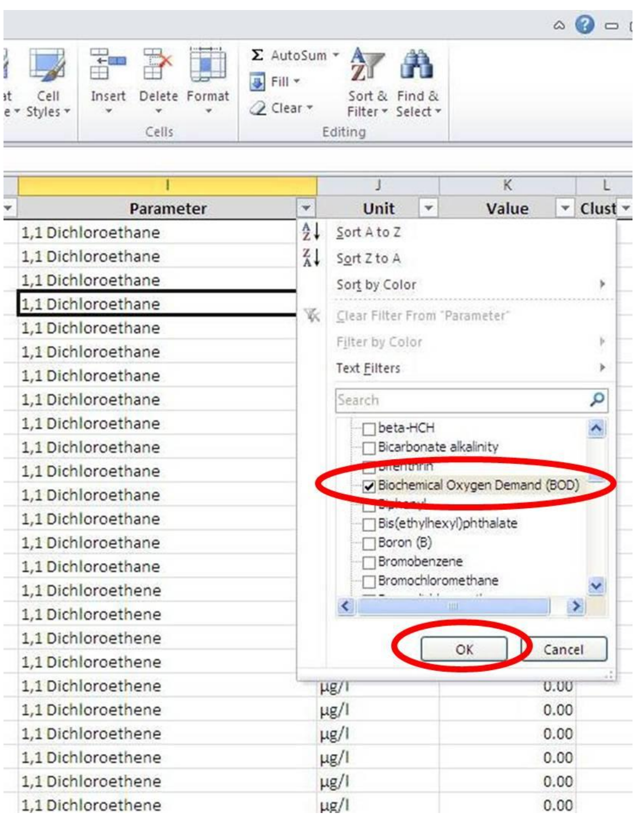
1.6. USING DATA – SORTING & FILTERING

All the information in the database can be sorted and filtered. The easiest way to do this is with the Filter function in Excel under Data → Sort & Filter → Filter. With this function, each category can then be isolated and required data obtained. For example, if one wanted to find Biochemical Oxygen Demand (BOD) results from 2011, the following actions would be taken.

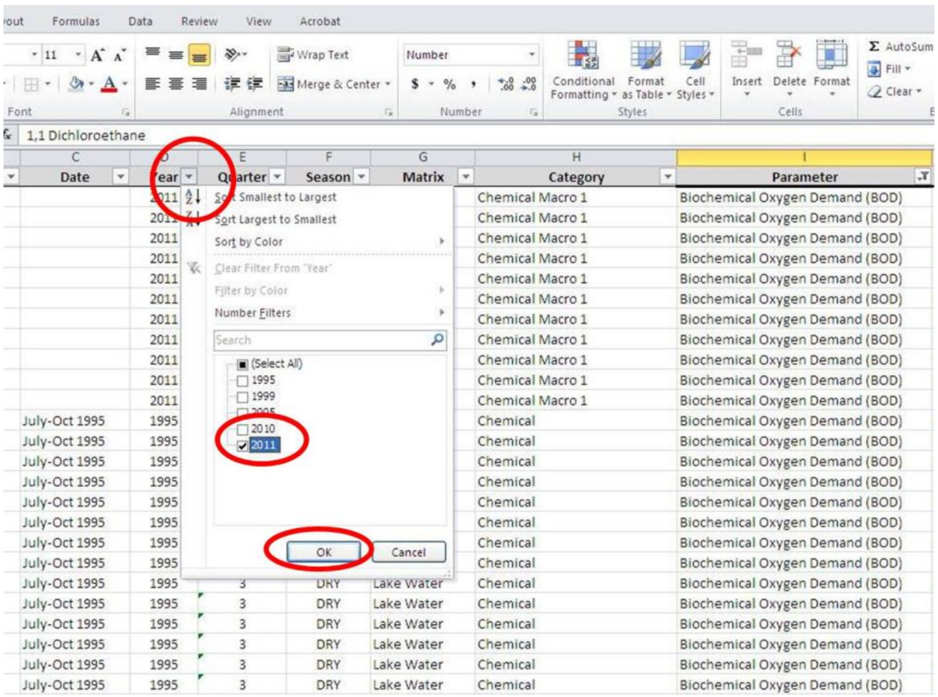
1. You will select the "Parameter" filter in order to get to Biochemical Oxygen Demand (BOD). When you first go to this category, you will want to unselect "(Select All)" so that all the options are cleared



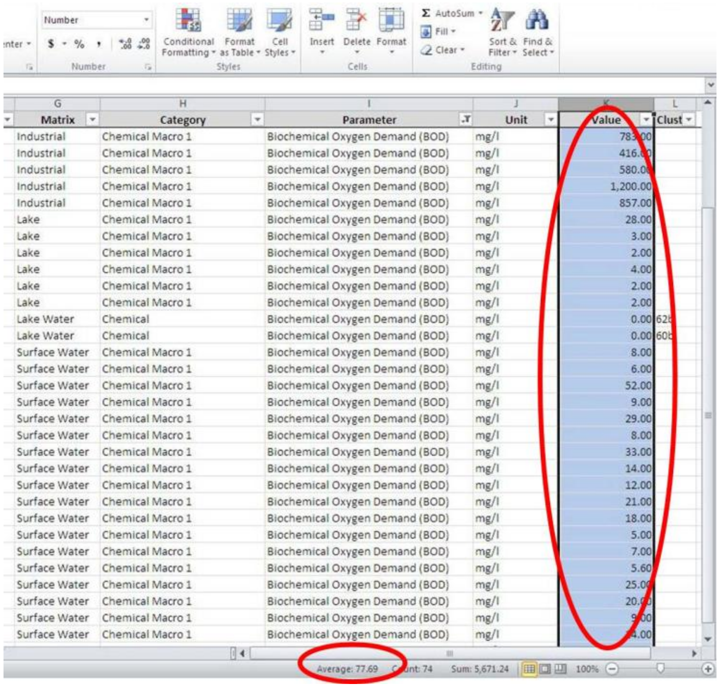
2. From the Parameter filter, you will want to select "Biochemical Oxygen Demand (BOD)" and then click "OK"



3. After you select Biochemical Oxygen Demand, this will display results for all sampling years. You will then want to go to the "Year" filter, and only select "2011", then click "OK".
4.



5. This will then display all the 2011 results of Biochemical Oxygen Demand. You can sort these results by the study in which they were conducted, source water, etc. Also, if you select the reported values, a brief summary will appear at the bottom that will also provide the average.



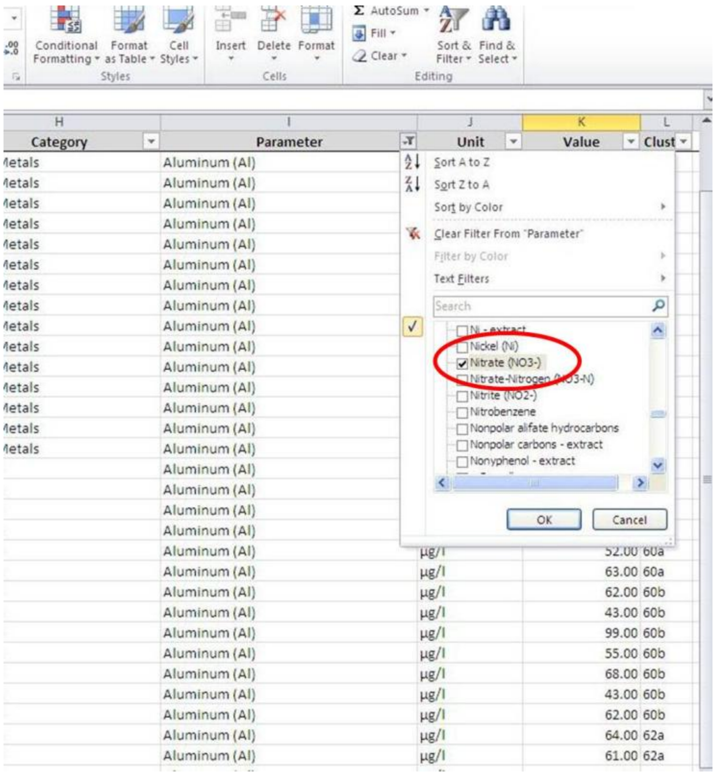
If you want to perform further analysis on these results, as outlined in the above Database Consistency Section, it is recommended that data is copied and pasted into a new sheet or workbook or saved under a separate name in order to create charts and graphs.

1.7. USING DATA – ANALYSIS

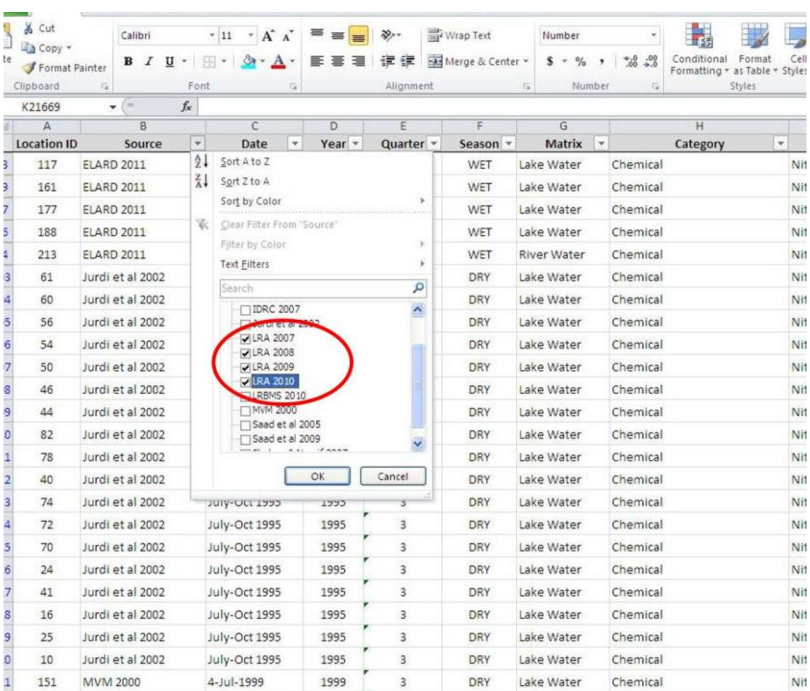
In order to create graphical displays of data in Excel the following steps should be taken. As outlined in the above section, reports can be generated in the main database through sorting and selecting appropriate data.

If one wanted to develop a historical graph of the nitrate (NO_3) concentration at the Berdawni River based on the LRA's data, the following steps should be taken to develop the information.

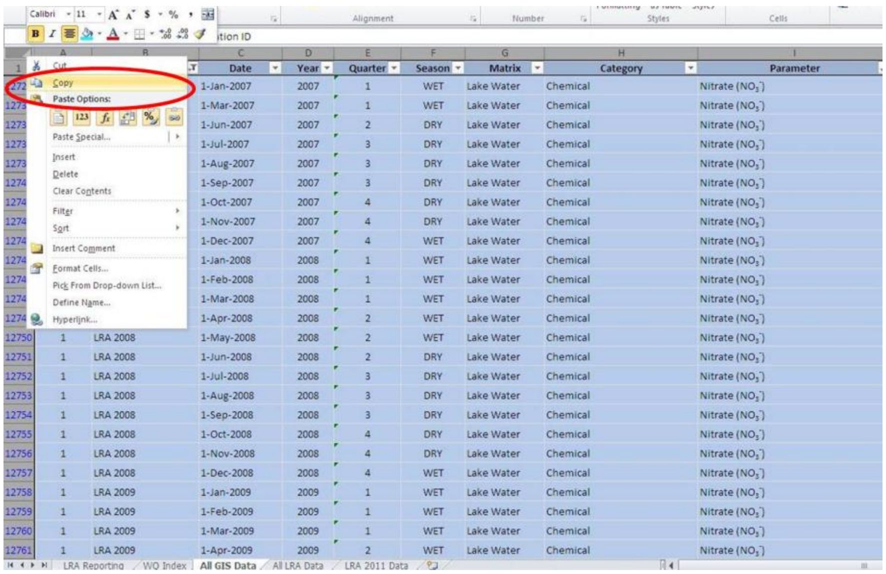
1. Perform a filter on the database, and select "Nitrate (NO3)" under the parameter category



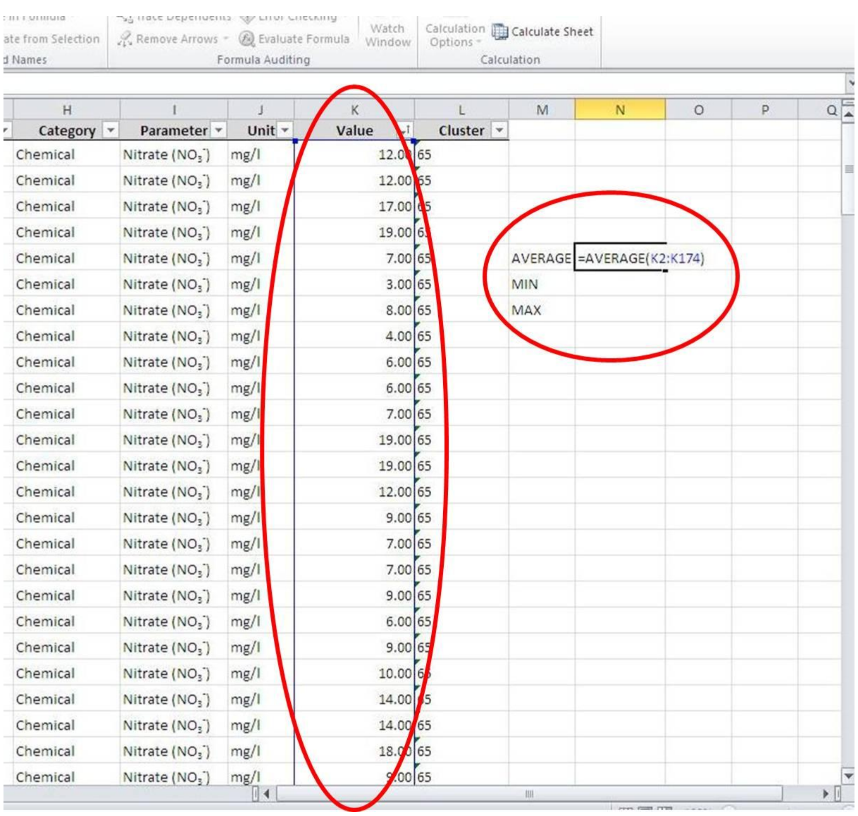
2. Then under "Source" a secondary filter should be applied to only select the LRA studies



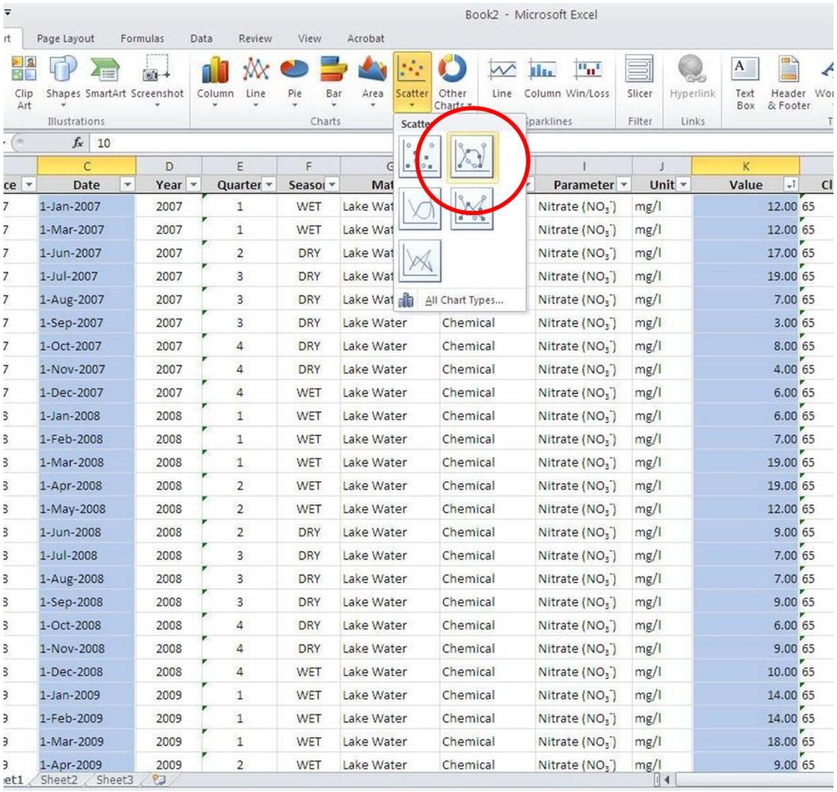
3. In order to align with the recommended version control, the filtered parameters should be selected and then copied and pasted into a new sheet or workbook



4. If desired, the average, minimum and maximum can be found by highlighting the data set and using the corresponding Excel functions

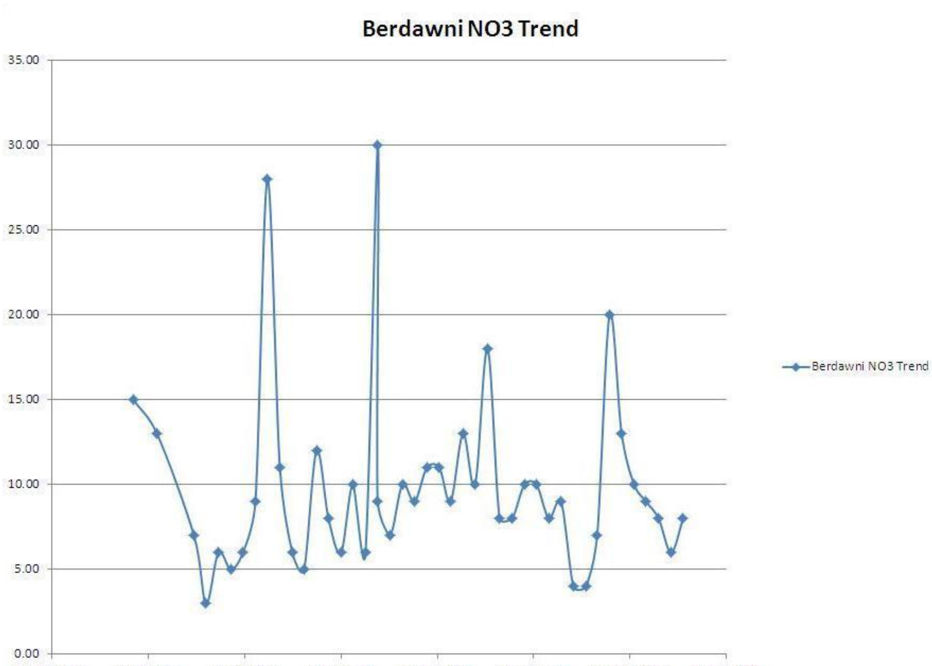


5. To plot the data historically, this can be done with a scatter plot and then selecting the time period and the measured values.



Date	Year	Quarter	Season	Mat		Parameter	Unit	Value	Cl
1-Jan-2007	2007	1	WET	Lake Wat		Nitrate (NO_3^-)	mg/l	12.00	65
1-Mar-2007	2007	1	WET	Lake Wat		Nitrate (NO_3^-)	mg/l	12.00	65
1-Jun-2007	2007	2	DRY	Lake Wat		Nitrate (NO_3^-)	mg/l	17.00	65
1-Jul-2007	2007	3	DRY	Lake Wat		Nitrate (NO_3^-)	mg/l	19.00	65
1-Aug-2007	2007	3	DRY	Lake Wat		Nitrate (NO_3^-)	mg/l	7.00	65
1-Sep-2007	2007	3	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	3.00	65
1-Oct-2007	2007	4	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	8.00	65
1-Nov-2007	2007	4	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	4.00	65
1-Dec-2007	2007	4	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	6.00	65
1-Jan-2008	2008	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	6.00	65
1-Feb-2008	2008	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	7.00	65
1-Mar-2008	2008	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	19.00	65
1-Apr-2008	2008	2	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	19.00	65
1-May-2008	2008	2	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	12.00	65
1-Jun-2008	2008	2	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00	65
1-Jul-2008	2008	3	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	7.00	65
1-Aug-2008	2008	3	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	7.00	65
1-Sep-2008	2008	3	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00	65
1-Oct-2008	2008	4	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	6.00	65
1-Nov-2008	2008	4	DRY	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00	65
1-Dec-2008	2008	4	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	10.00	65
1-Jan-2009	2009	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	14.00	65
1-Feb-2009	2009	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	14.00	65
1-Mar-2009	2009	1	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	18.00	65
1-Apr-2009	2009	2	WET	Lake Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00	65

6. Finally, the historical plot is developed for Nitrate at the Berdawni River sampling location



1.8. PLOTTING DATA IN GIS

Plotting data is GIS is an incredibly effective means for representing data spatially throughout the basin. Different measures of water quality and data can be presented and tied to a specific location. Since the Excel-based database in now in the proper GIS format, the ability to plot information is readily accessible. Maps can be generated easily based on the desired parameters and the attributes to be included.

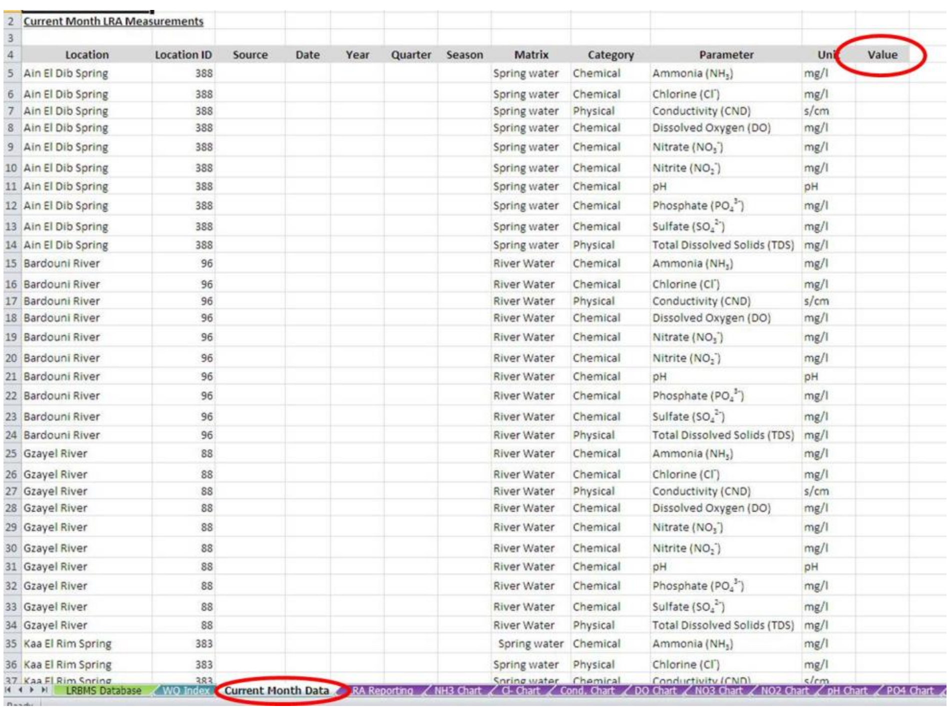
When generating maps in GIS, the GIS manager (or other team member trained in GIS) should assist with any plots. If general parameters or constraints are provided to the GIS manager, then output maps should be easily generated. GIS will also be relevant to the monthly reporting when Water Quality Index maps are used.

2. REPORTING

One of the most useful aspects of the Water Quality Database is the ability to use the data for reporting to stakeholders. The database has been set up to provide more technical data to the LRA and other ministries, while also providing information to the public. This section walks through the reporting with the database and how to generate reports.

2.1. TECHNICAL REPORTING

Templates were developed in order to report water quality data to LRA staff and ministries along with municipalities in the Bekaa Valley (outlined in the subsequent section). These templates correspond with the water quality database, and the integration of data into the templates is fairly straight-forward. Once the data is collected for the month being reported, it is entered into sheet labeled "Current Month Data", and then copied and pasted into the bottom of the main database sheet "LRBMS Database".



Current Month LRA Measurements

	Location	Location ID	Source	Date	Year	Quarter	Season	Matrix	Category	Parameter	Uni	Value
5	Ain El Dib Spring	388						Spring water	Chemical	Ammonia (NH_3)	mg/l	
6	Ain El Dib Spring	388						Spring water	Chemical	Chlorine (Cl^-)	mg/l	
7	Ain El Dib Spring	388						Spring water	Physical	Conductivity (CND)	s/cm	
8	Ain El Dib Spring	388						Spring water	Chemical	Dissolved Oxygen (DO)	mg/l	
9	Ain El Dib Spring	388						Spring water	Chemical	Nitrate (NO_3^-)	mg/l	
10	Ain El Dib Spring	388						Spring water	Chemical	Nitrite (NO_2^-)	mg/l	
11	Ain El Dib Spring	388						Spring water	Chemical	pH	pH	
12	Ain El Dib Spring	388						Spring water	Chemical	Phosphate (PO_4^{3-})	mg/l	
13	Ain El Dib Spring	388						Spring water	Chemical	Sulfate (SO_4^{2-})	mg/l	
14	Ain El Dib Spring	388						Spring water	Physical	Total Dissolved Solids (TDS)	mg/l	
15	Bardouni River	96						River Water	Chemical	Ammonia (NH_3)	mg/l	
16	Bardouni River	96						River Water	Chemical	Chlorine (Cl^-)	mg/l	
17	Bardouni River	96						River Water	Physical	Conductivity (CND)	s/cm	
18	Bardouni River	96						River Water	Chemical	Dissolved Oxygen (DO)	mg/l	
19	Bardouni River	96						River Water	Chemical	Nitrate (NO_3^-)	mg/l	
20	Bardouni River	96						River Water	Chemical	Nitrite (NO_2^-)	mg/l	
21	Bardouni River	96						River Water	Chemical	pH	pH	
22	Bardouni River	96						River Water	Chemical	Phosphate (PO_4^{3-})	mg/l	
23	Bardouni River	96						River Water	Chemical	Sulfate (SO_4^{2-})	mg/l	
24	Bardouni River	96						River Water	Physical	Total Dissolved Solids (TDS)	mg/l	
25	Gzayel River	88						River Water	Chemical	Ammonia (NH_3)	mg/l	
26	Gzayel River	88						River Water	Chemical	Chlorine (Cl^-)	mg/l	
27	Gzayel River	88						River Water	Physical	Conductivity (CND)	s/cm	
28	Gzayel River	88						River Water	Chemical	Dissolved Oxygen (DO)	mg/l	
29	Gzayel River	88						River Water	Chemical	Nitrate (NO_3^-)	mg/l	
30	Gzayel River	88						River Water	Chemical	Nitrite (NO_2^-)	mg/l	
31	Gzayel River	88						River Water	Chemical	pH	pH	
32	Gzayel River	88						River Water	Chemical	Phosphate (PO_4^{3-})	mg/l	
33	Gzayel River	88						River Water	Chemical	Sulfate (SO_4^{2-})	mg/l	
34	Gzayel River	88						River Water	Physical	Total Dissolved Solids (TDS)	mg/l	
35	Kaa El Rim Spring	383						Spring water	Chemical	Ammonia (NH_3)	mg/l	
36	Kaa El Rim Spring	383						Spring water	Physical	Chlorine (Cl^-)	mg/l	
37	Kaa El Rim Spring	383						Spring water	Chemical	Conductivity (CND)	s/cm	

LRBMS Database | WQ Index | Current Month Data | RA Reporting | NH3 Chart | Cl- Chart | Cond. Chart | DO Chart | NO3 Chart | NO2 Chart | pH Chart | PO4 Chart

Once the data has been entered into the "Current Month Data" sheet, it is auto-filled into the template sheet for monthly reporting titled "LRA Reporting". This data is then compared against the baseline data that has been collected by the LRA from 2007-2011.

LRA Monthly Reporting

Ammonia (NH_3)

	Units	Ain El Dib Spring	Bardouni River	Gzayel River	Kaa El Rim Spring	Khraizat Spring	Lake Qaraoun	Litani River (Jeb Janine)	Lucy Wells	Qeb Elias Spring	Shamsine Spring
Month Average	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historical Baseline Average (2007 - 2011)	mg/L	0.46	14.61	0.24	0.48	0.18	0.57	6.60	0.16	0.18	0.20

Chlorine (Cl^-)

	Units	Ain El Dib Spring	Bardouni River	Gzayel River	Kaa El Rim Spring	Khraizat Spring	Lake Qaraoun	Litani River (Jeb Janine)	Lucy Wells	Qeb Elias Spring	Shamsine Spring
Month Average	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historical Baseline Average (2007 - 2011)	mg/L	-	104.10	58.98	-	-	54.88	91.28	-	-	-

Conductivity (CND)

	Units	Ain El Dib Spring	Bardouni River	Gzayel River	Kaa El Rim Spring	Khraizat Spring	Lake Qaraoun	Litani River (Jeb Janine)	Lucy Wells	Qeb Elias Spring	Shamsine Spring
Month Average	s/cm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historical Baseline Average (2007 - 2011)	s/cm	334.45	701.11	418.84	227.35	352.35	398.38	636.58	511.56	301.15	405.79

Dissolved Oxygen (DO)

	Units	Ain El Dib Spring	Bardouni River	Gzayel River	Kaa El Rim Spring	Khraizat Spring	Lake Qaraoun	Litani River (Jeb Janine)	Lucy Wells	Qeb Elias Spring	Shamsine Spring
Month Average	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historical Baseline Average (2007 - 2011)	mg/L	5.93	4.60	5.17	6.22	6.18	6.92	4.14	6.29	5.73	6.09

Nitrate (NO_3^-)

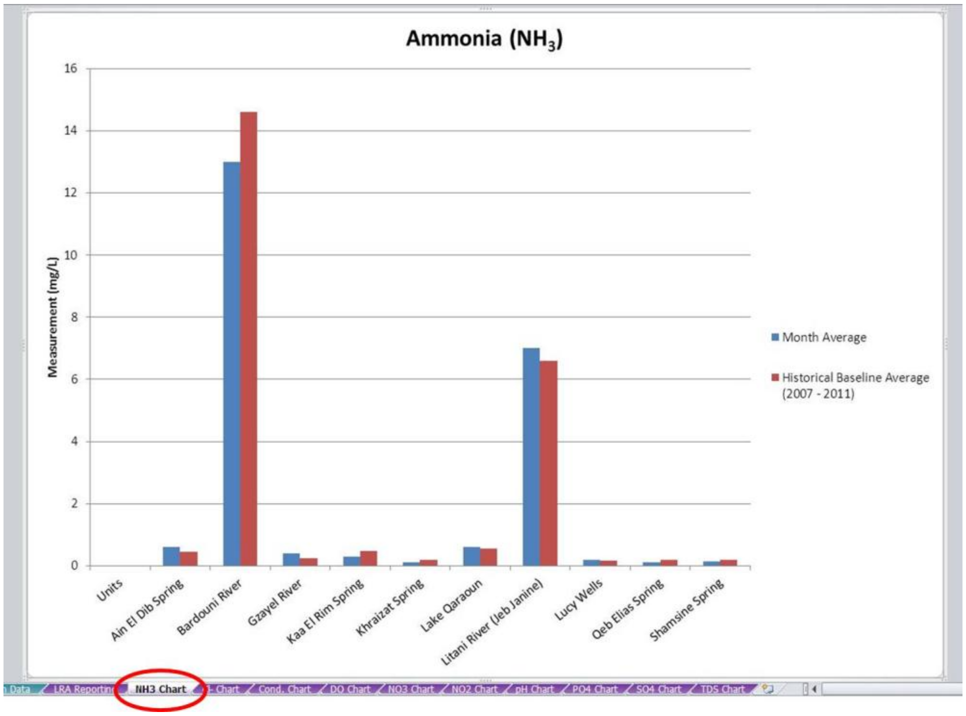
	Units	Ain El Dib Spring	Bardouni River	Gzayel River	Kaa El Rim Spring	Khraizat Spring	Lake Qaraoun	Litani River (Jeb Janine)	Lucy Wells	Qeb Elias Spring	Shamsine Spring
Month Average	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Historical Baseline Average (2007 - 2011)	mg/L	8.60	10.82	10.96	8.70	9.45	12.65	11.54	36.16	8.63	11.15

Nitrite (NO_2^-)

LRBMS Database | WQ Index | Current Month Data | LRA Reporting | NH3 Chart | Cl- Chart | Cond. Chart | DO Chart | NO3 Chart | NO2 Chart

Ready

Once the current month information is entered into the appropriate sheet, and subsequently auto-filled into the "LRA Reporting" tab, charts are auto-generated as graphical displays of the data. An example is shown below of the Ammonia tab.



When the tables and charts are generated, they should be copied and pasted into "Technical Reporting" template in Word for distribution. This reporting may later be integrated into Microsoft Access for easier interfaces, although Excel and Word are the first step for monthly reports.

The Water Quality Index (WQI) is also used in monthly reporting to the municipalities. The WQI is calculated based on a site, where the parameters are entered into the "WQI" tab in the database. The Q-values are then determined based on the website sources in the webpages.

2.1.1. HISTORICAL BASELINE AVERAGES

Similar to the overall Water Quality Database, an accompanying spreadsheet was developed that has historical averages for all the LRA's water quality data. This spreadsheet is used for reporting purposes and is a baseline comparison to current samples as shown in the "LRA Reporting" tab of the database. The data range of these historical baseline samples is from 2007 through 2011.

If data was added for a different baseline range (i.e. at the end of 2012), then in order the update the data in the historical averages, the new data would need to be added to the bottom of each parameter sheet.

Nitrate Baseline Averages

Location	2007	2008	2009	2010	2011	Overall Average
Ain El Dib Spring	7.22	6.92	7.50	9.90	11.45	8.60
Bardouni River	10.22	9.92	10.42	8.90	14.62	10.82
Gzayel River	9.67	8.82	11.83	12.30	12.17	10.96
Kaa El Rim Spring	8.11	7.42	8.90	10.20	8.87	8.70
Khraizat Spring	8.78	8.92	8.80	9.90	10.86	9.45
Lake Qaraoun	9.78	10.00	12.42	11.40	19.66	12.65
Litani River (Jeb Janine)	11.33	10.49	10.25	10.70	14.95	11.54
Lucy Wells	47.67	33.83	27.60	27.50	44.18	36.16
Qeb Elias Spring	7.00	7.17	8.78	10.00	10.21	8.63
Shamsine Spring	11.00	10.08	12.10	10.30	12.29	11.15

Shamsine Spring	382	LRA 2010	September	2010	3	DRY	Spring water	Chemical	Nitrate (NO_3^-)	mg/l	12.00
Shamsine Spring	382	LRA 2010	October	2010	4	DRY	Spring water	Chemical	Nitrate (NO_3^-)	mg/l	12.00
Shamsine Spring	382	LRA 2011	January	2011	1	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	2.48
Shamsine Spring	382	LRA 2011	February	2011	1	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	10.00
Shamsine Spring	382	LRA 2011	March	2011	1	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	19.00
Shamsine Spring	382	LRA 2011	April	2011	2	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	10.00
Shamsine Spring	382	LRA 2011	May	2011	2	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	16.00
Shamsine Spring	382	LRA 2011	June	2011	2	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	13.00
Shamsine Spring	382	LRA 2011	July	2011	3	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	12.00
Shamsine Spring	382	LRA 2011	August	2011	3	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	11.00
Shamsine Spring	382	LRA 2011	September	2011	3	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	15.00
Shamsine Spring	382	LRA 2011	October	2011	4	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	21.00
Shamsine Spring	382	LRA 2011	November	2011	4	DRY	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00
Shamsine Spring	382	LRA 2011	December	2011	4	WET	Spring Water	Chemical	Nitrate (NO_3^-)	mg/l	9.00

Reference Locations / Database Input / NH3 / Clorine / Conduct. / DO / NO3 / NO2 / pH / Phosphate / Sulfate / TDS

Ready

Once the data has been added, a new average would need to be developed for the locations and the corresponding year. Then a new historical baseline average would be developed by changing the range in the overall table at the top. This data could then be used for updated monthly reporting.

Nitrate Baseline Averages

Location	2007	2008	2009	2010	2011	2012	Overall Average
Ain El Dib Spring	7.22	6.92	7.50	9.90	11.45		8.60
Bardouni River	10.22	9.92	10.42	8.90	14.62		=AVERAGE(B6:G6)
Gzayel River	9.67	8.82	11.83	12.30	12.17		AVERAGE(number1, [number2], ...)
Kaa El Rim Spring	8.11	7.42	8.90	10.20	8.87		8.70
Khraizat Spring	8.78	8.92	8.80	9.90	10.86		9.45
Lake Qaraoun	9.78	10.00	12.42	11.40	19.66		12.65
Litani River (Jeb Janine)	11.33	10.49	10.25	10.70	14.95		11.54
Lucy Wells	47.67	33.83	27.60	27.50	44.18		36.16
Qeb Elias Spring	7.00	7.17	8.78	10.00	10.21		8.63
Shamsine Spring	11.00	10.08	12.10	10.30	12.29		11.15
Shamsine Spring	382 LRA 2010	September	2010	3	DRY		Spring water Chemical Nitr

2.1. PUBLIC REPORTING

Reporting information to the public is critical for stakeholders to understand the current water quality situation. Since most residents are not water quality experts, it is important to present information in a way that a larger number of people can understand. Therefore, a monthly report was developed that uses a simple and straight-forward Water Quality Index.

2.1.1. DEVELOPING A WATER QUALITY INDEX (WQI)

A Water Quality Index (WQI) is a valuable tool for providing information about the overall health of a waterway. It can summarize a large amount of water quality data for reporting to management and the public in a consistent manner. Typical water quality reports consist of complex statistical summaries that are variable-by-variable for each water body. The WQI allows water quality data to be compiled and reported in a consistent manner.

Further information on the Water Quality Index is provided in Appendix B as "Litani River Water Quality Index".

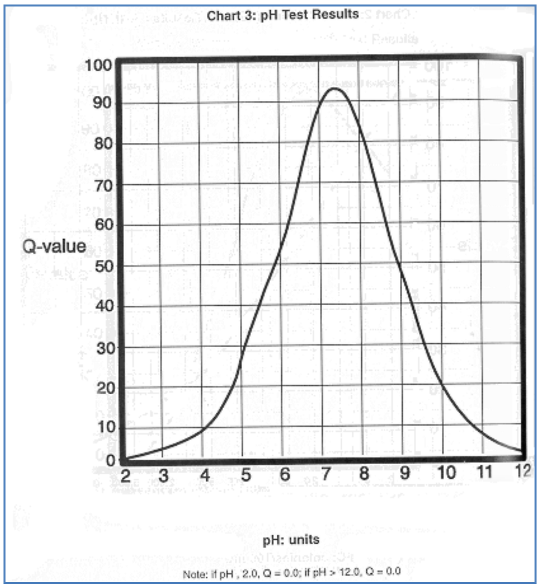
The Water Quality Index Scores are reported as a total number between 1 and 100. This is further simplified with descriptive categories. The category ranges may be modified depending on the variables and objective chosen but should be kept consistent between water bodies. The below table outlines the quality ranges.

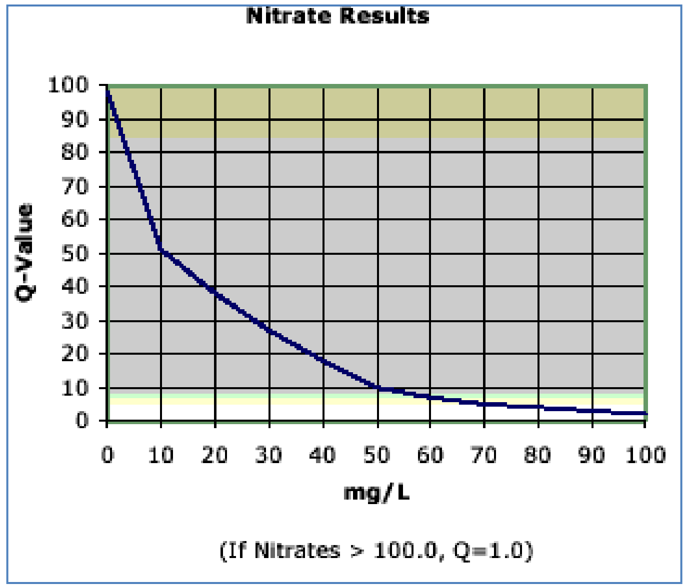
WQI Value	Classification	Meaning
90-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.
75-90	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
60-75	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
40-60	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0-40	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

How to use Water Quality Index within the Litani River

In order to generate a water quality index for the Litani River, a modified method was developed based on the availability of data and applicability. To generate the overall WQI, various water quality curves are used, which is based off the *Field Manual for Water Quality Monitoring* (2000).

These WQI curves correspond the measured concentration to a Q-value which factors into the over WQI calculation. The example Q-Value charts for pH and Nitrate are shown below.





To get the Q-Value, the concentration is entered into the webpage, and the Q-Value obtained. The webpage(s) for where to get the values are listed in the table below.

Parameter	**Source**	**Comment**
Temperature		Not a WQI parameter, although used in the Dissolved Oxygen Calculation
Dissolved Oxygen	www.fivecreeks.org/monitor/do.shtml	
Nitrate	www.water-research.net/watrqualindex/waterqualityindex.htm	
pH	www.water-research.net/watrqualindex/waterqualityindex.htm	
Phosphate	www.water-research.net/watrqualindex/waterqualityindex.htm	
Total Solids	www.water-research.net/watrqualindex/waterqualityindex.htm	Take TDS measurement and add 50 mg/L to account for TSS

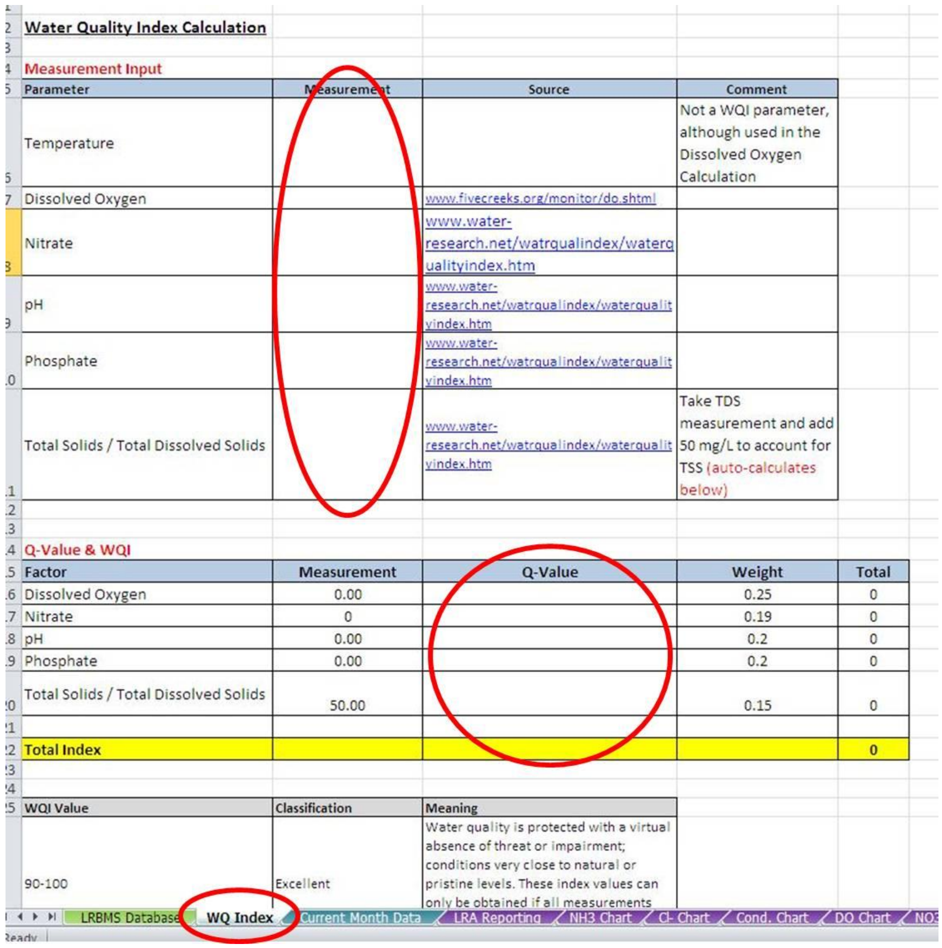
Dissolved Oxygen: In the Dissolved Oxygen calculation, elevation and temperature are required. For most locations in the Bekaa Valley, the elevation can be assumed at 900m. Elevation is not a critical factor in the equation, although temperature should be known and factored in to calculate the Dissolved Oxygen Q-Value.

Total Solids: Total Solids is a measurement of both Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). TDS is the main measurement taken by the LRA sampling, although TSS has been less frequently sampled. A baseline average of TSS is the Litani River can be assumed at 50 mg/L. In order to get Total Solids, this average 50 mg/L should be added to the Total Dissolved Solids measurement (i.e. if the TDS measurement is 200 mg/L, then the Total Solids for the Water Quality Index will be 250 mg/L)

These parameters are then assigned a weight to achieve the overall Water Quality Index. The weights for the Litani River Water Quality Index are listed below.

Parameter	**Weight**
Dissolved Oxygen	0.25
Nitrate	0.20
pH	0.20
Phosphate	0.20
Total Solids	0.15

Within the database, the Litani Water Quality Index is under the tab "WQ Index". The monthly parameters are entered into the "Measurement" column of the sheet, and then the Q-Values are obtained from the website sources listed. Once the Q-Values are determined, they are then multiplied by the corresponding weight, and totaled to generate the overall WQI for the sample set. The overall WQI then corresponds to the above ranges of quality data between 0 and 100.



Water Quality Index Calculation

Measurement Input

Parameter	Measurement	Source	Comment
Temperature			Not a WQI parameter, although used in the Dissolved Oxygen Calculation
Dissolved Oxygen		www.fivecreeks.org/monitor/do.shtml	
Nitrate		www.water-research.net/watrqualindex/waterqualityindex.htm	
pH		www.water-research.net/watrqualindex/waterqualityindex.htm	
Phosphate		www.water-research.net/watrqualindex/waterqualityindex.htm	
Total Solids / Total Dissolved Solids		www.water-research.net/watrqualindex/waterqualityindex.htm	Take TDS measurement and add 50 mg/L to account for TSS (auto-calculates below)

Q-Value & WQI

Factor	Measurement	Q-Value	Weight	Total
Dissolved Oxygen	0.00		0.25	0
Nitrate	0		0.19	0
pH	0.00		0.2	0
Phosphate	0.00		0.2	0
Total Solids / Total Dissolved Solids	50.00		0.15	0
Total Index				0

WQI Value	Classification	Meaning
90-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements

LRBMS Database | WQ Index | Current Month Data | LRA Reporting | NH3 Chart | Cl- Chart | Cond. Chart | DO Chart | NO3

Ready

For example, December 2011 data is used below to demonstrate the Water Quality Index for Jeb Janine. From these measurements the following Q-Values are developed from the corresponding webpages.

Parameter	Measurement	Q-Value
Temperature	18 °C	-
Dissolved Oxygen	2.50 mg/L	15
Nitrate	12.0 mg/L	48
pH	7.71	91
Phosphate	1.90 mg/L	28
Total Solids	515 mg/L (465 + 50 mg/L)	20

Then the weighting factors are applied to the Q-Values to come up with a Quality Index for the measurements. When totaled, these equal the total Water Quality Index for the December 2011 sampling at Jeb Janine.

Parameter	**Q-Value**	**Weight**	**Quality Index**
Dissolved Oxygen	15	0.25	4
Nitrate	48	0.20	10
pH	91	0.20	18
Phosphate	28	0.20	6
Total Solids	20	0.15	3
Total Water Quality Index			**41**

3. APPENDIX A – DATABASE SELECTION SUMMARY

To determine the best method for managing and analyzing water quality data, a brief assessment was conducted of the various programs and methods available.

The process for managing water quality data within the LRA currently involves a member of the LRA staff going to the field to collect samples monthly. There are 10 sampling sites throughout the Litani basin that collect 10 water quality parameters. This data is then retained is Excel format within the Water Quality department of the LRA. The parameters collected monthly throughout the basin include:

Parameter
Ammonia (NH_3)
Chlorine (Cl^-)
Conductivity (CND)
Dissolved Oxygen (DO)
Nitrate (NO_3^-)
Nitrite (NO_2^-)
pH
Phosphate (PO_4^{3-})
Sulfate (SO_4^{2-})
Total Dissolved Solids (TDS)
Salinity (limited measurements)

In going forward, the goal of the LRBMS database is to have a simple yet functional method for storing and analyzing water quality data. A number of methods were evaluated, which included Excel, GIS, and Aquachem.

Microsoft Excel

Excel is a simple method for managing data that allows samples to be catalogued, filtered, and sorted by various parameters. There is flexibility with Excel that allows users to make new sheets while displaying and analyzing data at their discretion, this is especially useful with time-based plots. Excel does not have internal capabilities to interpret water chemistry or provide conclusions on what the samples mean. An advantage of Excel is that it is typically the foundation to most database programs and can easily transition between other database methods such as Access or external products.

Geographic Information System (GIS)

GIS is a database system that uses northing and easting coordinates to spatially display data. It is useful with water quality data because parameters can be categorized while being graphed in comparison with other landmarks. The data within GIS can modified and plotted in accordance with target audience and needs. GIS is built on a Microsoft Access platform and can easily use Excel-based spreadsheets. GIS is not able to analyze data or draw conclusions on interactions in water chemistry. It can do some time-based graphical summaries, although typically Excel is better for this function.

AquaChem

AquaChem is a program design by Schlumberger Water Services and was initially designed with the purpose of analyzing groundwater in oil fields. AquaChem manages water quality data, allowing the user to plot data, perform common statistical analyses, model water chemistry, and create simple reports. AquaChem is compatible with Microsoft Office; and the database can be opened and modified in MS Access and data can be imported to AquaChem from text formatted and Excel files.
There are statistical tools with the AquaChem software that include trend analysis (Mann-Kendall, linear), normality tests, and evaluation of correlation between parameters. Although, database management and report preparation may be as easily performed in Excel and Access, the statistical tools in AquaChem can create aquatic chemistry diagrams to analyze and present data.

Recommendation for LRBMS and the LRA

In reviewing the capabilities of AquaChem, it is a powerful tool for analyzing specific aspects of water chemistry and the interactions of specific constituents. Although, the methods for analysis can be very complex, and in order to use this tool, training would be required of someone within the LRA's staff. In addition, someone on staff would need to be able to understand and interpret the water chemistry results. AquaChem could be considered as the LRA moves forward, although at the time being, resources may be better used by managing data in a simpler method.

Given that almost all advanced water quality databases use Microsoft Excel or Access as the fundamental data-keeper, it is recommended that Excel be used as the primary database. This will be the most simple and straight-forward method for managing and sorting data as required. In addition, GIS should continue to be retained in order to provide spatial representation throughout the basin. This has been a very effective method for the LRMBS thus far, and has been able to provide crucial decision-making maps for the program.

4. APPENDIX B – WATER QUALITY INDEX

Litani River Water Quality Index

Referenced from the Canadian Council of Ministers of the Environment (CCME)

<u>What is a water quality index?</u>

A water quality index is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. Similar to the UV index or an air quality index, it can tell us whether the overall quality of water bodies poses a potential threat to various uses of water, such as habitat for aquatic life, irrigation water for agriculture and livestock, recreation and aesthetics, and drinking water supplies.

Traditional reports on water quality typically consist of complex variable-by-variable, and water body-by-water body statistical summaries. This type of information is of value to water quality experts, but may not be meaningful to residents who want to know about the state of their local water bodies and for managers and policy makers who require concise information about those water bodies. The index also allows water quality data to be compiled and reported in a consistent manner.

<u>What information does a water quality index convey?</u>

Many water quality variables (e.g., acidity, fecal coliforms, dissolved oxygen) are compared to water quality guidelines or site-specific objectives. The results of those comparisons are combined to provide a water quality ranking (good, average, poor) for individual water bodies. The actual variables used are those which are important for the particular water body.

The importance of site-specific objectives and their selection are crucial to obtaining the most meaningful results from the WQI. The index can incorporate Lebanese water quality guidelines or guidelines from other jurisdictions when site-specific water quality objectives are not available, so that comparisons can be made for different water uses (e.g. aquatic life, drinking water, and recreation).

The advantages of an index include its ability to represent measurements of a variety of variables in a single number, its ability to combine various measurements in a variety of different measurement units in a single metric and its effectiveness as a communication tool. When the same objectives and variables are used, the index can be used to convey relative differences in water quality between sites over time.

How are index results reported or what do the index scores mean?

Once the WQI value has been determined, the result can be further simplified by assigning it to a descriptive category. The following categories are suggested as a starting point. The category ranges may be modified depending on the variables and objective chosen but this will depend on the water bodies and variables being dealt with through a process of comparing the index rank to expert opinion about the water body.

WQI Value	Classification	Meaning
90-100	Excellent	Water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.
75-90	Good	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.
60-75	Fair	Water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.
40-60	Marginal	Water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.
0-40	Poor	Water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

How to use Water Quality Index within the Litani River

In order to generate a water quality index for the Litani River, a modified method was developed based on the availability of data and applicability. To generate the overall WQI, various water quality curves are used, which is based off the *Field Manual for Water Quality Monitoring* (2000). These curves correspond the measured concentration to a Q-value which factors into the overall WQI calculation.

To get the Q-Value, the concentration is entered into the webpage, and the Q-Value obtained. The webpage(s) for where to obtain the values are listed in the table below.

Parameter	**Source**	**Comment**
Temperature		Not a WQI parameter, although used in the Dissolved Oxygen Calculation
Dissolved Oxygen	www.fivecreeks.org/monitor/do.shtml	
Nitrate	www.water-research.net/watrqualindex/waterqualityindex.htm	
pH	www.water-research.net/watrqualindex/waterqualityindex.htm	
Phosphate	www.water-research.net/watrqualindex/waterqualityindex.htm	
Total Solids	www.water-research.net/watrqualindex/waterqualityindex.htm	Take TDS measurement and add 50 mg/L to account for TSS

<u>Dissolved Oxygen</u>: In the Dissolved Oxygen calculation, elevation and temperature are required. For most locations in the Bekaa Valley, the elevation can be assumed at 900m. Elevation is not a critical factor in the equation, although temperature should be known and factored in to calculate the Dissolved Oxygen Q-Value.

<u>Total Solids</u>: Total Solids is a measurement of both Total Suspended Solids (TSS) and Total Dissolved Solids (TDS). TDS is the main measurement taken by the LRA sampling, although TSS has been less frequently sampled. A baseline average of TSS is the Litani River can be assumed at 50 mg/L from past sampling programs. In order to get Total Solids, this average 50 mg/L should be added to the Total Dissolved Solids measurement (i.e. if the TDS measurement is 200 mg/L, then the Total Solids for the Water Quality Index will be 250 mg/L)

These parameters are then assigned a weight to achieve the overall Water Quality Index. The weights for the Litani River Water Quality Index are listed below.

Parameter	Weight
Dissolved Oxygen	0.25
Nitrate	0.20
pH	0.20
Phosphate	0.20
Total Solids	0.15

Once the Q-Values are obtained from the website sources listed, they are then multiplied by the corresponding weight, and totaled to generate the overall WQI for the sample set. The overall WQI then corresponds to the above descriptive ranges of water quality data.

5. APPENDIX C – WATER QUALITY SAMPLING PARAMETERS

Parameter	Category
1,1 Dichloroethene	Volatile halogenated HC's
1,1,1- Trichloroethane	Volatile halogenated HC's
1,1,1,2-Tetrachloroethane	Volatile halogenated HC's
1,1,2,2-Tetrachloroethane	Volatile halogenated HC's
1,1,2-Trichloroethane	Volatile halogenated HC's
1,1-Dichloropropylene	Volatile halogenated HC's
1,2 Dichloroethane	Volatile halogenated HC's
1,2,3,4-Tetrachlorobenzene	Chlorinated Benzenes
1,2,3,5/1,2,4,5-Tetrachlorobenzene	Chlorinated Benzenes
1,2,3-Trichlobenzene	Chlorinated Benzenes
1,2,3-Trichloropropane	Volatile halogenated HC's
1,2,4-Trichlorobenzene	Chlorinated Benzenes
1,2,4-Trimethylbenzene	Mono Aromatic Hydrocarbons
1,2-Dibromo-3-chloropropane	Volatile halogenated HC's
1,2-Dibromoethane	Volatile halogenated HC's
1,2-Dichlorobenzene	Chlorinated Benzenes
1,2-Dichloropropane	Volatile halogenated HC's
1,3,5-Trichlorobenzene	Chlorinated Benzenes
1,3,5-Trimethylbenzene	Mono Aromatic Hydrocarbons
1,3-Dichlorobenzene	Chlorinated Benzenes
1,3-Dichloropropane	Volatile halogenated HC's
1,3-Dichloropropylene (sum)	Volatile halogenated HC's
1,4-Dichlorobenzene	Chlorinated Benzenes
1-Chloronaphtalene	Miscellaneous Chlor. HCs
2,2-Dichloropropane	Volatile halogenated HC's
2,3,4,5-Tetrachlorophenol	Chlorinated Phenols
2,3,4,6/2,3,5,6-Tetrachlorophenol	Chlorinated Phenols
2,3,4-Trichlorophenol	Chlorinated Phenols
2,3,5/2,4,5-Trichlorophenol	Chlorinated Phenols
2,3,5-Trichlorophenol	Chlorinated Phenols

2,3,6-Trichlorophenol	Chlorinated Phenols
2,3/3,4-Dichloronitrobenzene	Chloronitrobenzenes
2,3/3,5-Dimethylphenol + 4-Ethylphen	Phenols
2,3-Dichloronitrobenzene	Chloronitrobenzenes
2,3-Dichlorophenol	Chlorinated Phenols
2,4,5-Trichlorophenol	Chlorinated Phenols
2,4,6-Trichlorophenol	Chlorinated Phenols
2,4/2,5-Dichlorophenol	Chlorinated Phenols
2,4-DDD	Chlorine pesticides
2,4-DDE	Chlorine pesticides
2,4-Dichloronitrobenzene	Chloronitrobenzenes
2,4-Dimethylphenol	Phenols
2,5-Dichloronitrobenzene	Chloronitrobenzenes
2,5-Dimethylphenol	Phenols
2,6-dichlorophenol	Chlorinated Phenols
2,6-Dimethylphenol	Phenols
2-Chlorotoluene	Miscellaneous Chlor. HCs
3,4,5-Trichlorophenol	Chlorinated Phenols
3,4-Dichloronitrobenzene	Chloronitrobenzenes
3,4-Dichlorophenol	Chlorinated Phenols
3,4-Dimethylphenol	Phenols
3,5-Dichloronitrobenzene	Chloronitrobenzenes
3,5-Dichlorophenol	Chlorinated Phenols
4,4-DDD/2,4-DDT	Chlorine pesticides
4,4-DDE	Chlorine pesticides
4,4-DDT	Chlorine pesticides
4-Chloro-3-methylphenol	Chlorinated Phenols
4-Chlorotoluene	Miscellaneous Chlor. HCs
Acenaphtene	PAHs
Acenaphtylene	PAHs
Aldrin	Chlorine pesticides
Alfa-chlordane	Chlorine pesticides
Alfaendosulfan	Chlorine pesticides
Alfaendosulfansulphate	Chlorine pesticides
alfa-HCH	Chlorine pesticides
Alkalinity	Chemical
Alkyd naphthalene - extract	PAHs
Aluminum (Al)	Metals
Aluminum Oxide (Al_2O_3)	Metals
Ametryne	Nitrogen pesticides
Ammonia (NH_3)	Chemical

Ammonium (NH_4^+)	Chemical
Anthracene	PAHs
Antimony (Sb)	Metals
Arsenic (As)	Metals
Atrazine	Nitrogen pesticides
Azinphos-ethyl	Phosphor pesticides
Azinphos-methyl	Phosphor pesticides
Barium (Ba)	Metals
Benzene	Mono Aromatic Hydrocarbons
Benzo(a)anthracene	PAHs
Benzo(a)pyrene	PAHs
Benzo(b)fluoranthene	PAHs
Benzo(b/k)fluoranthene	PAHs
Benzo(ghi)perylene	PAHs
Benzo(k)fluoranthene	PAHs
Beryllium (Be)	Metals
beta-HCH	Chlorine pesticides
Bicarbonate alkalinity	Chemical
Bifenthrin	Miscellaneous pesticides
Biochemical Oxygen Demand (BOD)	Chemical
Biphenyl	Miscellaneous HCs
Bis(ethylhexyl)phthalate	Phthalates
Boron (B)	Metals
Bromobenzene	Volatile halogenated HC's
Bromochloromethane	Volatile halogenated HC's
Bromodichloromethane	Volatile halogenated HC's
Bromomethane	Volatile halogenated HC's
Bromophos-ethyl	Phosphor pesticides
Bromophos-methyl	Phosphor pesticides
Butylbenzylphthalate	Phthalates
Cadmium (Cd)	Metals
Calcium (Ca^{2+})	Chemical
Calcium Oxide (CaO)	Chemical
Carbaryl	Miscellaneous pesticides
Carbonate alkalinity	Chemical
Cd - extract	Metals
Chemical Oxygen Demand (COD)	Chemical
Chlordanes (sum)	Chlorine pesticides
Chlorine (Cl^-)	Chemical
Chloroethane	Volatile halogenated HC's

Chloromethane	Volatile halogenated HC's
Chloropyrophos-ethyl	Phosphor pesticides
Chloropyrophos-methyl	Phosphor pesticides
Chlorotoluenes (sum)	Miscellaneous Chlor. HCs
Chromium (Cr)	Trace Metals
Chrysene	PAHs
cis- 1,2 Dichloroethene	Volatile halogenated HC's
cis 1,3-Dichloropropylene	Volatile halogenated HC's
Clostridial Spores	Microbiological
Cobalt (Co)	Metals
Colour	Physical
Conductivity (CND)	Physical
Copper (Cu)	Metals
Cresoles (sum)	Phenols
Cumaphos	Phosphor pesticides
Cyanazine	Nitrogen pesticides
Cyanides Total	Cyanides
Cypermethrin (A,B,C,D)	Miscellaneous pesticides
DDT/DDE/DDD (sum)	Chlorine pesticides
delta-HCH	Chlorine pesticides
Deltamethrin	Miscellaneous pesticides
Demethon-S/Demethon-O (ethyl)	Phosphor pesticides
Desmetryne	Nitrogen pesticides
Diazinon	Phosphor pesticides
Dibenzo(ah)anthracene	PAHs
Dibenzofurane	Miscellaneous HCs
Dibromochloromethane	Volatile halogenated HC's
Dibromomethane	Volatile halogenated HC's
Dibutylphthalate	Phthalates
Dichlorobenzenes (sum)	Chlorinated Benzenes
Dichloromethane	Volatile halogenated HC's
Dichloronitrobenzenes (sum)	Chloronitrobenzenes
Dichlorophenols (sum)	Chlorinated Phenols
Dichlorovos	Phosphor pesticides
Dieldrin	Chlorine pesticides
Diethylphthalate	Phthalates
Di-isobutylphthalate	Phthalates
Dimethylphthalate	Phthalates
Di-n-octylphtalate	Phthalates
Dissolved Organic Carbon	Chemical
Dissolved Oxygen (DO)	Chemical

Dissolved Oxygen, 1-day (DO_1)	Chemical
Dissolved Oxygen, 5-day (DO_5)	Chemical
Disulfoton	Phosphor pesticides
Drins (sum)	Chlorine pesticides
Dry matter	Characteristics
E.coli	Microbiological
Endrin	Chlorine pesticides
Enterococci sp.	Microbiological
Ethylbenzene	Mono Aromatic Hydrocarbons
Fat Oil and Grease (FOG)	FOG
Fecal Coliforms	Microbiological
Fecal Streptococcus	Microbiological
Fenitrothion	Phosphor pesticides
Fenthion	Phosphor pesticides
Ferric Oxide (Fe_2O_3)	Metals
Fluoranthene	PAHs
Fluorene	PAHs
Gallium (Ga)	Metals
Gamma-chlordan2	Chlorine pesticides
gamma-HCH	Chlorine pesticides
HCH (sum)	Chlorine pesticides
Heptachlor	Chlorine pesticides
Heptachloroepoxide	Chlorine pesticides
Hexachlorobenzene	Chlorinated Benzenes
Hexachlorobenzene - extract	Chlorinated Benzenes
Hexachlorobutadiene	Chlorine pesticides
Hydroxide alkalinity	Chemical
Indeno(123cd)pyrene	PAHs
Inorganic carbon	Chemical
Iron (Fe)	Trace Metals
Isodrin	Chlorine pesticides
isopropylbenzene	Mono Aromatic Hydrocarbons
Lead (Pb)	Trace Metals
Linuron	Miscellaneous pesticides
Lithium (Li)	Metals
m/p- Xylene	Mono Aromatic Hydrocarbons
Magnesium (Mg)	Chemical
Magnesium Oxide (MgO)	Chemical
Malathion	Phosphor pesticides
Manganese (Mn)	Metals

Manganese Oxide (MnO)	Metals
m-Chloronitrobenzene	Chloronitrobenzenes
m-Chlorophenol	Chlorinated Phenols
m-Cresol	Phenols
Mercury (Hg)	Metals
m-Ethylphenol	Phenols
Molybdenum (Mo)	Metals
Monochlorobenzene	Chlorinated Benzenes
Monochloronitrobenzenes (sum)	Chloronitrobenzenes
Monochlorophenols (sum)	Chlorinated Phenols
Naphtalene	PAHs
n-Butylbenzene	Mono Aromatic Hydrocarbons
Ni - extract	Metals
Nickel (Ni)	Trace Metals
Nitrate (NO_3^-)	Chemical
Nitrate-Nitrogen (NO_3-N)	Chemical Macro 1
Nitrite (NO_2^-)	Chemical
Nitrobenzene	Miscellaneous HCs
n-Propylbenzene	Mono Aromatic Hydrocarbons
o,p'-DDD	Chlorine pesticides
o/p-Chloronitrobenzene	Chloronitrobenzenes
o-Chlorophenol	Chlorinated Phenols
o-Cresol	Phenols
o-Ethylphenol	Phenols
Orthophosphates	Chemical Macro 1
o-Xylene	Mono Aromatic Hydrocarbons
p,p' -DDD	Chlorine Pesticides
p,p'-DDD/o,p'-DDT	Chlorine pesticides
p,p'-DDE	Chlorine pesticides
p,p'-DDT	Chlorine Pesticides
PAHs (sum 10 Dutch VROM)	PAHs
PAHs (sum 16 US EPA)	PAHs
Parathion-ethyl	Phosphor pesticides
Parathion-methyl	Phosphor pesticides
Pb - extract	Metals
PCB (sum 6)	PCB
PCB (sum 7)	PCB
PCB 101	PCB
PCB 118	PCB
PCB 138	PCB

PCB 153	PCB
PCB 180	PCB
PCB 28	PCB
PCB 52	PCB
p-chlorophenol	Chlorinated Phenols
p-Cresol	Phenols
Pentachlorobenzene	Chlorinated Benzenes
Pentachlorophenol	Chlorinated Phenols
Permethrin	Miscellaneous pesticides
Permethrin (sum)	Miscellaneous pesticides
Permethrin A	Miscellaneous pesticides
Permethrin B	Miscellaneous pesticides
pH	Chemical
Phenanthrene	PAHs
Phenol	Phenols
Phosphate (PO_4^{3-})	Chemical
Phosphorus Pentoxide (P_2O_5)	Chemical
Phthalates (sum)	Phthalates
p-Isopropyltoluene	Mono Aromatic Hydrocarbons
Potassium (K)	Chemical Macro 2
Potassium Oxide (K_2O)	Chemical
Prometryne	Nitrogen pesticides
Propachloor	Miscellaneous pesticides
Propazine	Nitrogen pesticides
Pyrazophos	Phosphor pesticides
Pyrene	PAHs
Rb (Rubidium)	Metals
S (Sulphur)	Chemical
Salinity	Physical
sec-Butylbenzene	Mono Aromatic Hydrocarbons
Selenium (Se)	Metals
Silicone (Si)	Chemical
Silocone Dioxide (SiO_2)	Chemical
Silver (Ag)	Metals
Simazine	Nitrogen pesticides
Sodium (Na)	Chemical Macro 2
Strep Fecalis	Microbiological
Strontium (Sr)	Metals
Styrene	Mono Aromatic Hydrocarbons
Sulfate (SO_4^{2-})	Chemical Macro 1

Tedion	Chlorine pesticides
Telodrin	Chlorine pesticides
Temperature	Physical
Terbutryne	Nitrogen pesticides
Terbutylazine	Nitrogen pesticides
tert-Butylbenzene	Mono Aromatic Hydrocarbons
Tetrachlorobenzene (sum)	Chlorinated Benzenes
Tetrachloroethanes (sum)	Volatile halogenated HC's
Tetrachloroethene	Volatile halogenated HC's
Tetrachloromethane (tetra)	Volatile halogenated HC's
Tetrachlorophenols (sum)	Chlorinated Phenols
Thymol	Phenols
Tin (Sn)	Metals
Titanium Dioxide (TiO_2)	Metals
Toluene	Mono Aromatic Hydrocarbons
Total Carbon	Chemical
Total Coliforms	Microbiological
Total Dissolved Solids (TDS)	Physical
Total Hardness	Chemical
Total Nitrogen	Chemical
Total Organic Carbon (TOC)	Characteristics
Total Phosphorus (P)	Chemical
Total Phosphorus (P) - calculated	Chemical
Total Suspended Solids (TSS)	Physical
TPH (sum C10-C40)	Total Petroleum Hydrocarbons
TPH C10-C12	Total Petroleum Hydrocarbons
TPH C12-C16	Total Petroleum Hydrocarbons
TPH C16-C21	Total Petroleum Hydrocarbons
TPH C21-C30	Total Petroleum Hydrocarbons
TPH C30-C35	Total Petroleum Hydrocarbons
TPH C35-C40	Total Petroleum Hydrocarbons
tr-1,2 Dichloroethene	Volatile halogenated HC's
trans 1,3-Dichloropropylene	Volatile halogenated HC's
Triazophos	Phosphor pesticides
Tribromomethane (Bromoform)	Volatile halogenated HC's
Trichlorobenzene (sum)	Chlorinated Benzenes
Trichloroethanes (sum)	Volatile halogenated HC's
Trichloroethene	Volatile halogenated HC's
Trichlorofluoromethane	Volatile halogenated HC's
Trichloromethane (chloroform)	Volatile halogenated HC's
Trichlorophenols (sum)	Chlorinated Phenols

Trifluralin	Miscellaneous pesticides
Turbidity	Physical
Vanadium (V)	Metals
Vinylchlorine	Volatile halogenated HC's
Xylenes (sum)	Mono Aromatic Hydrocarbons
Yttrium (Y)	Metals
Zinc (Zn)	Metals
Zirconium (Zr)	Metals

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